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Progress Report

STUDIES OF THE BIOLOGY AND CONTROL OF THE BLACK-HEADED BUDWORM IN ALASKA

Season of 1955

by

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Forest Entomologist

Alaska Forest Research Center
R. F. Taylor, Forester in Charge
Juneau, Alaska
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TABLE OF CONTENTS

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SUMMARY

Studies of the black-headed budworm were continued for the third successive year during 1955. Major emphases were on investigations of seasonal weather variations and budworm development; effects of heavy budworm defoliation on second-growth western hemlock and Sitka spruce; effects of exposure and site in relation to budworm defoliation and damage to mature forests; and some natural control factors. The results of these investigations are briefly summarized as follows:

1. Seasonal weather variations have a decided influence on black-headed budworm development.

2. Cumulative average daily temperatures above 42° appear related to the development of the various budworm stages. More work is needed to substantiate these initial observations.

3. Two full growing seasons after the budworm epidemic swept through a second-growth stand of western hemlock all of the hemlock which suffered top kill still retained the dead top section. On the other hand, 84 percent of those trees supported new leader formation, originating for the most part from side branches at the bases of the dead sections.

4. Recovery of budworm-damaged second-growth Sitka spruce is well in progress two years after defoliation. Eighty-four percent of the spruce which were top killed have cast off the dead leaders and competition is now taking place to form new leader growth. This new growth is arising from bud clusters which formed in 1954 around the bases of the dead 1953 terminals. During the 1955 growing season, 81 percent of the trees which suffered loss of their terminals had one or more new leaders well formed. It must be determined whether those trees developing multiple leaders will become multiple stemmed.

5. Most of the black-headed budworm damage to mature hemlock stands occurs between elevations of 450 to 900 feet.

6. There may or may not be a weak tendency on the part of the budworm to cause most damage on north and east slopes.

7. Class 3 timber stands were most frequently damaged by the black-headed budworm. These stands contain a high percentage of volume in western hemlock.

INTRODUCTION

Investigations of the black-headed budworm were hampered this year by very poor weather and heavy parasitism in the study area. This parasitism reduced the already low budworm populations to still lower levels, making some investigations impractical while others had to be discontinued. Budworm populations are currently low over the entire Tongass National Forest and the outbreak which has been in evidence since 1947 has now subsided.

Major effort during the 1955 field season was directed toward the continuation of those studies concerned with susceptibility of mature stands to budworm damage and the effects of budworm defoliation on second-growth stands. Travel necessary to carry out survey activities prevented adequate concentration on budworm parasites since personnel had to be far removed from the study areas during some of the collection stages.

Credit is due David G. Wagstaff who assisted with the work described in this report.

BIOLOGY

Life History

For the third successive year the development of the black-headed budworm has been followed and the seasonal variations recorded. During this period of years, weather has varied considerably and these variations in turn have had pronounced effects on budworm development.

Table 1 presents a comparison of budworm development since 1953. Larval parasites destroyed the populations in 1955 and prevented a complete three year comparison.

Table 1.--Seasonal variation in black-headed budworm development. Data for 1953, 1954 and 1955. Juneau. Sea level

	1953	1954	1955
Egg hatching	May 29	June 2	June 13
5th instar reached	June 21	July 19	July 12
Pupation began	July 11	August 6	August 8
Moths emerging	July 31	August 17	Unknown
Oviposition began	Sept. 1	Sept. 15	Unknown

May, June and the first half of July, 1953, were warm with many clear days but with slightly above normal precipitation. During this period the black-headed budworm was able to complete all of its defoliation in a little less than 1½ months. The weather in 1955 was unusually cool and wet, with the exception of late spring and July, and the budworm was in the feeding stages for about two months.

On the other hand, the weather during the budworm growing period in 1954 did not seem unusually cold or wet, yet the budworm was in the feeding stage for over 2 months. Admitting some give or take in the actual dates of specific developmental stages, it can be seen that study of weather data and budworm development is confusing at best and that a more methodical system of relating the two should be employed. This was attempted using the system of cumulating daily temperatures above certain specified temperatures, in this case 42° F.

Previous studies of temperature in relationship to plant minimums have been investigated by many workers. These studies showed that 42° F. can be generally accepted as a reliable plant zero above which growth is possible1/. In general between 40°-45° F. is also the minimum temperature range below which insects cannot develop.

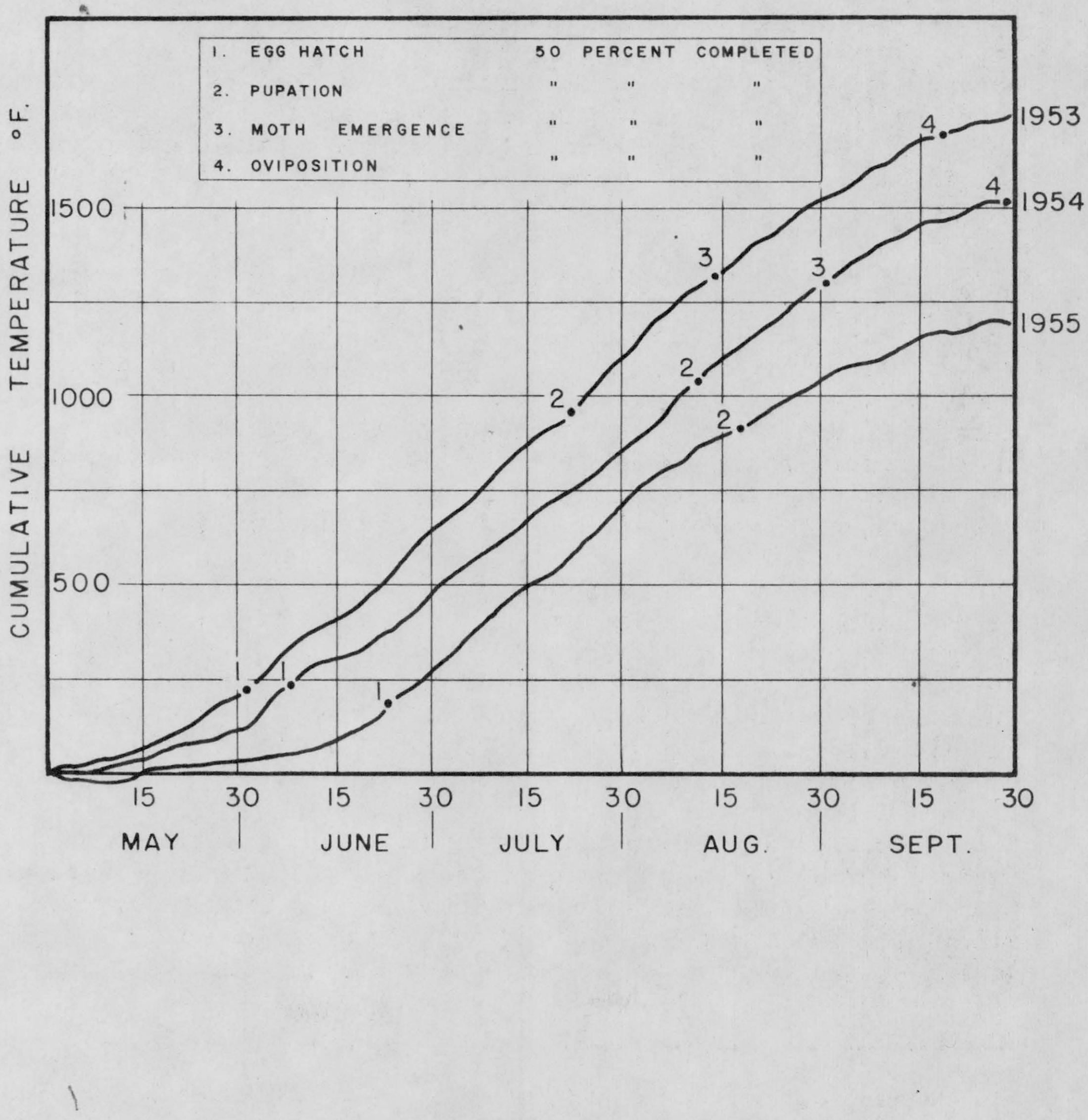
Using 42 degrees as a base, degrees above this were added cumulatively from average daily temperatures starting with the first day of that month whose average temperature was above 42° F. The relationship between cumulative degrees and the dates at which 50 percent of the various budworm stages were reached is shown in Figure 1. Most of these dates were determined by interpolating data taken at weekly intervals and are therefore fairly accurate. The dates for 50 percent oviposition are weak since they are rough approximations made from observations of moth frequency, initial oviposition and late moth flight.

Examination of the data presented in Figure 1 shows good correlation between cumulative degrees and the mid-points of the various budworm stages. One exception is noted; namely, the date of 50 percent pupation in 1954. The very short interval of time in the pupal stage might suggest that pupation was reached earlier than the samples indicated. If this was the case, the correlation between cumulative degrees and pupation would be strengthened.

The present data are somewhat meager for drawing conclusions. Parasites reduced the budworm populations so much in 1955 that the data are further weakened. Nevertheless, good correlations are indicated, which if substantiated by subsequent work will provide valuable information for timing control work and for certain biological investigations.

1/ Weaver, J. E. and F. E. Clements, 1929. Plant Ecology. McGraw Hill Co., N.Y. p. 291.

FIGURE I RELATIONSHIP BETWEEN BLACK-HEADED BUDWORM DEVELOPMENT AND CUMULATIVE AVERAGE DAILY TEMPERATURES ABOVE 42° F. *(Juneau, Alaska — Sea Level)*



DAMAGE

Effects of heavy budworm defoliation on second-growth western hemlock and Sitka spruce

The second-growth hemlock plot at Lemon Creek near Juneau was remeasured in 1955, two years after it suffered heavy defoliation and extensive damage. Improved techniques in remeasuring and the advantage of two growing seasons to check on trees listed as having doubtful top kill and complete defoliation, necessitated revision of the 1954 tabulated data. In effect these revisions are corrections to tables 4 and 5 in the 1954 report.

Table 2 shows the characteristics of the second-growth hemlock plot in 1953, at the time of heavy budworm defoliation and the results of budworm feeding as measured in 1955. Ten small spruce on the plot, none of which were attacked, are not shown.

Table 2.--1953 characteristics of hemlock second-growth plot and effects of black-headed budworm feeding as shown in 1955.

	Dominants	Codominants	Intermediates	Overtopped
No. trees in 1953	54	46	110	122
Top kill by 1955, in percent	85	52	10	1
Top kill by 1955, av. length, ft.	2	1	1	0.2
% trees with complete top defoliation	95	91	31	6
Av. length of complete top defoliation, feet	6.7	3.8	1.0	0.16
1953 age at 1 foot* - years	27	27	26	25
1953 av. dbh - inches	4.2	3.5	2.3	1.5
1953 av. height - feet	27.25	24.00	20.66	16.33
1953 radial growth-rings per inch*	10.00	12.3	17.8	21.1

* Based on a sample of 10 trees in each crown class.

In the summer of 1955 the ten spruce trees continued to live, but eight hemlock had died because of overcrowding. Seven of these hemlock were suppressed while the eighth was classed as intermediate.

The remeasurement of budworm damage caused by the 1953 defoliation was accomplished by measuring each tree in each crown class rather than

taking a sample of ten trees per crown class as was done in 1954. The 100 percent measurement did not materially change the data for the lengths of top kill and complete defoliation, but the additional year of tree growth made the identity of top kill readily visible and pointed up errors in the 1954 data concerning the percent of hemlock stems top killed.

Two full growing seasons after the budworm epidemic swept through the study area, all of the hemlock trees which suffered top kill still retained the dead top section. On the other hand, 84 percent of those trees supported growth which could be classed as new leader growth; i.e. side branches that were assuming the position of leaders. Most of this new leader growth developed from single side branches at the bases of the dead sections, but a few trees have new leaders developing from bud growth. The average length of this new leader growth is just under twelve inches.

The second-growth Sitka spruce plot at Douglas was re-examined to follow the course of the 1953 defoliation and subsequent recovery.

The heavy budworm defoliation which occurred to spruce in 1953 caused mortality of that year's growth in 74 percent of all spruce trees on this plot. By 1955, 84 percent of those trees had dropped the dead terminal and new leader formation is in progress. This new leader formation is arising from bud clusters, often as many as twelve or more buds, which formed in 1954 around the bases of the dead 1953 terminals. During the 1955 growing season 19 percent of the trees contained terminal twig clusters of new growth in which no apparent leader was evident. Thirty-nine percent of the trees contained one shoot which was dominating all others; 40 percent of the trees contained two competing shoots from the bud clusters, and 2 percent of the trees contained four competing terminal shoots.

It remains to be determined whether this leader competition will result in permanent tree deformity such as multi-stemmed trees.

Effects of growth rate, crown position, species composition, site and exposure on susceptibility of mature hemlock to budworm defoliation

Studies under this general heading were continued during the summer of 1955 with emphasis placed on exposure and site in relation to budworm defoliation and damage. Previous investigations at Petersburg in mature hemlock forests showed the upper crown levels suffered greatest damage. No correlation was found between damage and growth rate of trees.

In 1953 an aerial survey of hemlock forests within the Ketchikan Pulp Company timber allotment was made for the purpose of mapping budworm damage within two miles of salt water. The area covered was the northeast half of Prince of Wales Island, the southern half of Etolin Island, the Cleveland Peninsula and all of Revillagigedo Island. In addition to the restriction that mapping would be confined to within two miles of salt water, no budworm defoliated areas were mapped unless at least half of the stems contained readily visible damage. Defoliation was then divided into two catagories; viz. (1) defoliation visible throughout less than half the crown length, and (2) defoliation visible throughout more than half the crown length.

Defoliated areas were mapped on U. S. Geological Survey topographic sheets or U. S. Forest Service topographic timber type maps of various scale but none smaller than approximately 6.5 miles per inch. The results of this survey are presented in table 3. Slope exposures are by quadrants as follows: Exposures from 315° to 45° considered North; 45° to 135° as East, etc. North and West extends from 225° to 45°.

Table 3 points out very markedly that most of the black-headed budworm damage occurs between elevations of 450 to 900 feet.

An additional 106 budworm-damaged hemlock stands were mapped in the Admiralty Lakes region on Admiralty Island during the summer of 1955. The elevation distribution of damaged areas was similar to that found on the Ketchikan Pulp Company allotment. The distribution on Admiralty Island was: 0' to 450' - 24 areas; 451' to 900' - 56 areas; 901' to 1350' - 26 areas. No areas were found above 1350'.

The histogram shown in Figure 2 below indicates the distribution of the Admiralty Lakes budworm-damaged areas plotted by 100-foot elevation classes. These elevation classes represent average elevations of the damaged areas. The distribution is similar to that found on the pulp allotment damaged areas.

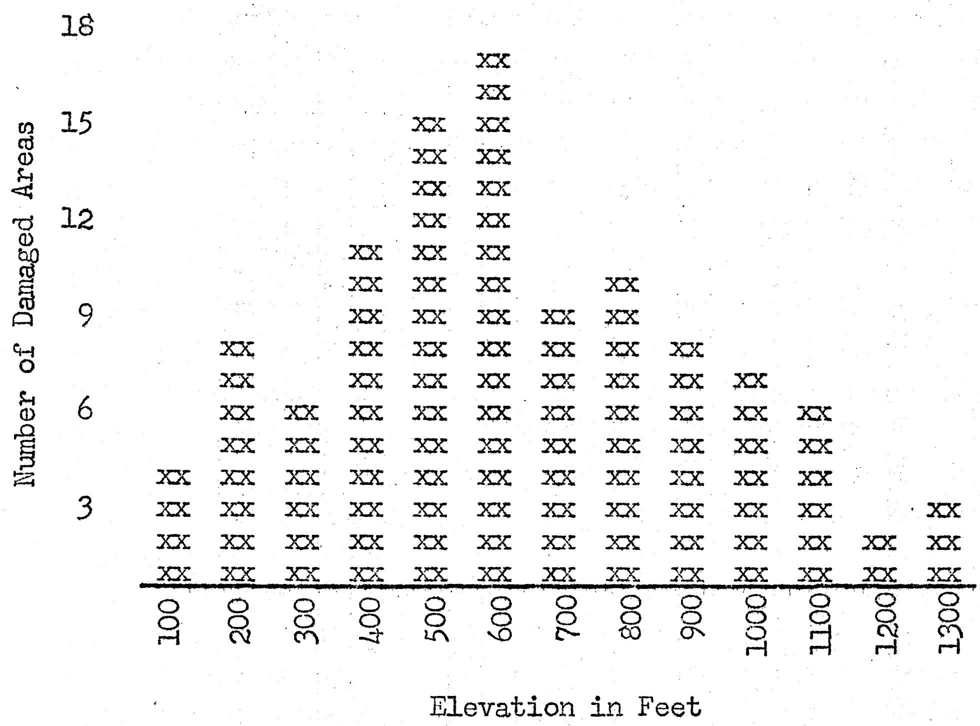


Figure 2.—Elevational distribution of black-headed budworm damaged areas in the Admiralty Lakes region, Tongass National Forest.

The exposure distribution of budworm-damaged areas on Admiralty Island varied somewhat from areas within the pulp allotment. In the Admiralty Lakes region, 35 areas were on north facing slopes, 22 on east, 7 on

Table 3.—Tabulation of number and size of areas by elevation class and exposure, damaged by the black-headed budworm

ELEVATION CLASS	NORTH		EAST		SOUTH		WEST		NORTH&EAST		NORTH & WEST		SOUTH & EAST		SOUTH & WEST		TOTAL	
	Acres	No. Areas	Acres	No. Areas	Acres	No. Areas	Acres	No. Areas	Acres	No. Areas	Acres	No. Areas	Acres	No. Areas	Acres	No. Areas	Acres	No. Areas
(a) MORE THAN HALF OF CROWN LENGTH DAMAGED																		
0' - 450'	690	2	280	2	30	2											1,000	6
451'- 900'	790	11	820	9	70	6	55	5	370	2	190	1			30	1	2,325	35
901'-1350'	30	1			205	4	70	4									305	9
1351' +							30	1									30	1
TOTAL	1510	14	1100	11	305	12	155	10	370	2	190	1			30	1	3,660	51
(b) LESS THAN HALF OF CROWN LENGTH DAMAGED																		
0' - 450'	437	9	75	2	780	2							120	1			1,412	14
451'- 900'	2216	16	5808	28	1167	14	1363	10	215	2	467	4	20	1			11,256	75
901'-1350'	182	5	50	1	143	4	53	4					640	1			1,068	15
1351' +	50	3			10	1											60	4
TOTAL	2885	33	5933	31	2100	21	1416	14	215	2	467	4	780	3			13,796	108
(c) COMBINATION OF (a) AND (b)																		
0' - 450'	1127	11	355	4	810	4							120	1			2,412	20
451'- 900'	3006	27	6628	37	1237	20	1418	15	585	4	657	5	20	1	30	1	13,581	110
901'-1350'	212	6	50	1	348	8	123	8					640	1			1,373	24
1351' +	50	3			10	1	30	1									90	5
TOTAL	4395	47	7033	42	2405	33	1571	24	585	4	657	5	780	3	30	1	17,456	159

south, 37 on west, 1 on north and east , and 3 on north and west. The exposure preference on Admiralty Island is definitely north and west. In the pulp allotment areas north and east were most frequently damaged.

Additional budworm-damaged areas on Mitkof and Wrangell Islands should be mapped to strengthen this exposure preference data. At the present time, it appears that there is little or no exposure preference shown by the budworm.

Godman[2/] has classified the climax forests of Southeast Alaska into five classes based on the number of 16-foot logs in and above the average diameter class. The classification does more than set down stand classes according to the number of logs. It lists a series of characteristics which help to locate and define the stands in considerable detail. During the 1953 aerial mapping of budworm-damaged areas within the Ketchikan Pulp allotment, an attempt was made to record the class of each damaged area with the hope of relating damage to species composition and volume.

A total of 121 damaged areas were classified from the air and the average log-height class of those damaged areas was found to be 2.9; hereafter more practically considered as class 3. Class 3 with four 16-foot logs in and above the average diameter tree is the median log-height class in Godman's system which ranges from class 5 (2 logs) to class 1 (6 logs).

The percent of volume by species in class 3 stands is as follows: spruce - 9 percent, hemlock - 71 percent, and cedar - 20 percent. On the other hand, class 2 stands contain 74 percent hemlock volume, 16 percent spruce and 10 percent cedar. The fact that the class 2 stands did not appear to suffer as much budworm damage as class 3 stands does not weaken the opinion that the percent of hemlock in the stands has direct bearing on susceptibility. In the first place, the difference of 3 percent in hemlock volume between the classes is probably too slight to be significant. In the second place, class 3 stands have more trees 8 inches and larger than are found in class 2 stands and it is logical to expect the ratio of hemlock trees is greater in class 3. The greater number of trees would certainly tend to offset the lower hemlock volume in reference to budworm susceptibility.

During the course of mapping budworm damage, no 2-log (scrub) or 6-log (sawtimber with high spruce volume) stand classes were observed to be damaged.

The distribution of log-height classes by slope, aspect, and elevation was considered by Godman. Attempting to relate budworm damage to this distribution presents some confusion and little positive correlation. Class 3 stands were found by Godman to occupy east and west aspects in the majority of cases. Budworm damage in the Admiralty Lakes region was mostly on north and west aspects, and in the pulp allotment areas mostly on north and east aspects. The greatest percentage of class 2 and class 1

2/ Godman, R. M. 1952. A classification of the climax forests of southeastern Alaska. Journal of For., 50:435-438.

stands were found on south aspects where budworm damage was frequently light. This would be expected if areas contained many class 1 stands; i.e. stands with considerable spruce.

Most of the budworm damage was found between 450' to 900' elevation. Most of the class 3 stands are above 800', but by far the greatest percent of class 2 stands are within the elevation range of maximum budworm damage. At this point it becomes evident that further attempts to relate budworm damage to the log-height classification are too perplexing until refined budworm damage data are available.

NATURAL CONTROL FACTORS

Black-headed budworm populations in the Juneau area were very light in 1955 making adequate parasite sampling very time-consuming in the early budworm stages and completely impractical in later stages which had been further depleted by parasites.

Egg parasitism by Trichogramma minutum Riley was found to range from 0.8 percent to 5.4 percent in the Juneau area. The lesser degree of parasitism was found in the areas of greatest budworm population.

Larval parasitism was observed until it became impractical to sample further due to low budworm populations. On August 8 when the last parasite examination was made, 86 percent of the larvae were either dead or parasitized. Found within or adjacent to larval bodies or remains were Microgaster peroneae Walley - 44 percent, Actia diffidens new. - 22 percent and Elachertus sp. - 6 percent. Cause of death in the remaining 14 percent of the larval bodies could not be determined.

Damaged bud and needle clusters were very frequently found to contain pupae of Elachertus sp. with no obvious budworm larval remains. These pupae were found in about 33 percent of all damaged needle clusters at the time of the parasite examination referred to above.

Elachertus sp. were first noticed as common during the summer of 1954. Parasite pupae which developed from 1954 budworm larvae were collected on April 27, 1955. At that time 100 pupae were collected from only 248 damaged needle clusters. Peak chalcid emergence occurred under laboratory rearings from this collection on May 2.

FURTHER RESEARCH NEEDS

There is presently some discrepancy between what should be done and what is practical to do concerning further research on the black-headed budworm. Budworm populations are so low in areas where study could be carried out that little advance seems possible with the limited effort which is financially permissible. The desire for study during endemic conditions is recognized.

With the resources available and the need for such information, best expenditure of effort seems to be in determining the significance of budworm damage. In this connection it is proposed to continue the study of the effects of budworm defoliation on second-growth western hemlock and Sitka spruce. The amount of tree mortality in heavily defoliated mature stands should be determined and the delayed recovery or eventual death of trees in such stands should be followed.